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The Psychosocial Variables in Accidents: A Process Model

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THE PSYCHOSOCIAL VARIABLES IN ACCIDENTS: A PROCESS MODEL

by

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VITA

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CHAPTER I

INTRODUCTION

Accidents are the fourth leading cause of death in the United States, following heart disease, cancer, and stroke (National Safety Council, 1984). Occupational accidents have been decreasing over the years, but currently they are still a significant concern of industry. A 1984 census report (National Safety Council, 1985) stated that accidental deaths in the United States related to work totalled 1,900,000. For 1983, the Occupational Safety and Health Administration (OSHA) estimates that 5.4 work-related deaths occurred per 100,000 United States employees. According to the aforementioned census, United States accidents cost industry $33.4 billion in 1984 (36% of the total national accident cost) due to wage loss, medical expenses, insurance administration costs, fire loss, and indirect costs arising out of the work accidents.

Industrial occupations such as mining, steel and machinery manufacturing, railroading, etc., have systemic control systems run by safety committees, engineers, and technological experts that focus on the physical hazards in the work environment. These systems operate in conjunction with federal, state, local, industrial, and OSHA regulations and standards (Kantowitz & Sorkin, 1983). A large percentage of occupational accidents are the result of human error rather than environmental hazard. Systemic control systems are not as effective as they could be since they do not deal with the human error component of accidents.

Considering the large percentage of accidents caused by human error, it is surprising to find that research on the psychosocial variables contributing to occupational accidents has been somewhat neglected. If the variables that contribute to human error are determined, a means of predicting human error and hence accidents can be established. This study will provide an organized descriptive theory of the psychosocial risk factors that lead to occupational accidents.

The study will have practical value as well in diagnosing safety problems and thus aiding in the development of control procedures to reduce losses. Management and the work force of industry can benefit immensely by the saving of lives and money and the lessening of human injuries. Once the significant contributors to accidents are established for several industries, future research can attempt to generalize the results to other industries. In the very long run, research can attempt to apply this knowledge to accidents in non-occupational settings such as traffic, the home, and public situations.

The remainder of the dissertation is organized into four chapters. Chapter II is a synthesis of the relevant literature in the area of psychosocial variables in occupational accidents. A discussion of the existing research on the relationship of physical hazards, demographics, safety management, stress and anxiety, and perceived control to accidents is included. The chapter concludes with the proposal of an integrative model of the variables leading to accidents.

Chapter III describes the methodology used in the study to test the proposed model. The aspects of the methodology included in this chapter are: independent and dependent variables investigated, respondents used, instrument used, procedure followed, and analysis conducted.

Chapter IV reports the findings of the statistical analyses used in the study. Results of the factor analysis, reliability analysis, correlations between survey variables, correlations between survey variables and accidents, path analysis, overall regressions, and cross-validations are included in this report.

The final chapter begins with a discussion of the findings, their support of the model, and their theoretical relevance. The limitations of the study are discussed subsequently. The chapter concludes with sections on the practical implications of the study and suggestions for future research.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter concentrates on a review of the literature of the psychosocial variables related to occupational accidents. The variables are categorized in five major sections: physical hazards and danger level, demographics, safety management, stress and anxiety, and perceived control. The chapter ends with an elaboration of a proposed path model which describes how each variable relates to occupational accidents.

Several relevant books on the subject of psychosocial variables related to accidents were located through the card catalog. Computer searches were conducted through Psychological Abstracts, Social Science Contents, Social Science Abstracts, Index Medicus, Engineering Contents, and National Institute of Occupational Safety and Health (NIOSH) Reports with the following terms: occupational accidents, injuries, and deaths with stress, anxiety, manufacturing, safety , and health. Investigation of this literature revealed a hodgepodge of studies focusing on only one or two variables and no studies were found which attempted to integrate findings from the various disciplines into an integrative theory. Combining the variables from each of the studies resulted in a list of predictive variables. These variables fell into five general categories and are detailed in the following sections.

Physical Hazards/Danger Level

A rather obvious finding is that physical hazards (e.g., falling rock, fires, broken tools, etc.) contribute to the accident rate. Human error alone is not enough to cause an accident. There must be some physical hazard present for an injury to occur. The degree to which physical hazards contribute to accidents depends, of course, on the severity of these hazards. Blignaut (1979) reports that in examining accident records of a South African mine, 40% of the accidents were caused by pure physical hazard, particularly falling rock. Sixty percent of these accidents, however, were caused primarily by human error, specifically inaccurate hazard perception. In these cases, the accident could have been avoided if the miner had perceived a warning and took corrective action. Lawrence (1974) also found that 60% of gold mining accidents were due to human error (e.g., missing a warning, forgetting a safety rule) and 40% were caused by pure physical hazard which the miner could not avoid.

Other hazardous occupations, such as primary steel manufacturing (processing iron ore to steel) and airline piloting have fewer physical hazards to deal with and thus more of their accidents are primarily caused by human error. McCarron and Haakonson (1979) in their study of airline piloting, report that accidents are caused by human error in 80% of the cases; 20% are caused by pure physical hazards. The same percentages have been reported for primary steel manufacturers (Guastello, Ikeda, & Connors, 1985).

In summary, accidents are due largely to human error but a certain amount of hazard is necessary for an accident to occur. A measure of hazard is essential for any complete model of the accident process.

Demographics

Another rather obvious finding is that the major white-collar occupational groups generally have lower work-injury rates than their blue-collar counterparts, according to information from the Bureau of Labor Statistics (National Safety Council, 1982). Using 1978 data from 25 states, the Bureau found that blue-collar workers comprised 48% of the employment population yet accounted for 77% of injuries compared to white-collar workers who made up 30% of the employment population yet only 8% of work injuries. This phenomenon is largely due to the fact that a greater degree of physical hazard exists in blue-collar jobs than in white-collar jobs.

Size of the work group an individual belongs to has been shown to relate to accidents. In a review article, Revans (1958) reported three studies which found a negative relationship, two a curvilinear relationship, and one a positive relationship between group size and accident rate. Conway et al. (1981) reported that accidents decrease as age, years of experience doing similar work, and seniority with the company increase. Females are reported to have fewer accidents than males.

Safety Management

Several attributes of safety program management have been found to discriminate between manufacturing organizations with high versus low accident rates (Smith, Cohen, Cohen, & Cleveland, 1978; Zohar, 1980). The list includes: perceived importance of safety training, status of the safety officer, status of safety committee, reward and punishment structure for safe and unsafe conduct, availability and use of protective safety equipment, and housekeeping behavior. Also, it is important to have appropriate role models of safety for employees to observe, a general climate that endorses safety, and a reinforcement program for appropriate safety behavior.

Rather than simply presenting a group of tips for safety managers, Zohar (1980) emphasized the idea of a climate for safety, where climate for safety can be thought of as a special case of organizational climate. The concept is not unfounded since earlier research on many subgroups found that accidents, absenteeism, turnover, job satisfaction and climate variables all vary together across organizational subgroups (Knowles, 1975). One purpose of the present research is to expand the climate concept beyond safety management issues only, to include other objective (i.e., physical hazard) and affective (i.e., stress, anxiety, and locus of control) concepts as well.

Controlling the pace at which employees need to work to keep up with production quotas is another important characteristic of a good safety management program. Chiles (1982) found that job overload, which causes employees to work under time pressures, results in errors. Effectively managing task pace should reduce errors, thus decreasing the accident rate.

Stress and Anxiety

Stressors may be organized into two categories: those that are physical in origin, and those that are social in origin.

Physical Stress. The relationship of physical stressors (such as heat, cold, noise, toxins, dust, lack of light, and crowdedness) to errors has been widely researched (Cohen, 1980) and shown to negatively affect performance on certain tasks. Excess noise has been shown to inhibit task performance (Glass & Singer, 1972; Zimmer & Brachulis, 1978) as well as increase accident rates (Noweir, 1984; Wilkins & Action, 1982). Performance on both physical and mental tasks has been reported to be adversely affected by excessive heat (Hancock, 1980) and prolonged exposure to cold temperatures (Kantowitz & Sorkin, 1983).

Shiftwork has also been shown to be related to performance. The basic concept behind shiftwork research is that shiftwork (i.e., any work other than the regular 6:00 a.m.- 2:00 p.m., 7:00 a.m.- 3:00 p.m., 8:00 a.m.- 4.p.m., or 9:00 a.m.- 5:00 p.m hours, involving a second shift, night shift, or rotating shifts) has a deleterious effect on most people's performance (Guastello, 1982). The unwanted effects on performance and well being have been attributed to disturbance of circadian rhythms and normal sleep patterns (Bell & Telman, 1980; Borowsky & Wall, 1983; Ribak et al., 1983).

Social Stress. It has been demonstrated that personal and social stressors predict physical illness. Holmes and Rahe (1967) have developed a Life Events Scale which includes a checklist of stressful events such as the death of a relative, a divorce, etc. An overall score is obtained for any individual by adding the specific stress values assigned to each individual item.

Research has demonstrated that those individuals receiving high scores are more likely to suffer an illness in the next two years than those individuals receiving low scores. Levenson (1983) found through post-accident interviews that those employees who had accidents had been experiencing more life stressors before the accident than those employees not involved in accidents.

Fairly recent studies have shown that stressful events may immediately precede automobile and domestic accidents as well as industrial accidents (Whitlock, Stoll , & Rekhdahl, 1977). Brenner and Selzer (1969) found that automobile drivers who experienced recent social stress were five times more likely to cause fatal accidents as drivers without such stress.

Anxiety. Manifest anxiety as measured by the Taylor Manifest Anxiety Scale (1953) is often indicative of stress in a person's life -- either physical or social stress. The anxiety scale which was derived from the Minnesota Multi-Phasic Inventory (MMPI) is a collection of medical symptoms which do not go together logically. These symptoms could be precipitated by stressful events or they could be a neurotic disorder independent of any stressful events. Persons experiencing many life stressors and/or physical stressors but exhibiting little anxiety may be "resistant to stress" (Zarzycka, 1982), a trait found to be a predictor of low accident rates.

Some associations have been made between anxiety and accident rates. Casualities in one automobile plant had longer past histories of medical, surgical, and psychiatric episodes (Allodi & Montgomery, 1979). Hirschfeld and Behan (1963), in reviewing 300 cases of industrial accidents leading to disability, emphasized that accidents are part of a process in which both stress and anxiety dominate the pre-accident setting, slow down recovery, and prolong disability. Japanese pilots who were accident victims were found to be experiencing many anxiety symptoms preceding the incident (Kakimoto, Katoh, Nakabayashi, & Iwamoto, 1983).

The previously mentioned studies that examined stress and anxiety levels before an accident are suspect with regard to validity since subjects were studied after an accident in order to determine their stress and anxiety levels before the accident. One cannot help but wonder about the accuracy of this recall method.

Perceived Control

It has been established that uncontrollable physical stressors such as noise, heat, and crowding lead to greater error than controllable ones (Glass & Singer, 1972). For example, if a person has the option of turning down the heat, that person will experience less stress (regardless of whether he or she actually turns the heat down) than the person who has no option other than bearing it (Cohen, 1980). Three theories have been proposed to explain this phenomenon and they are described as follows.

Adaptive-cost Hypothesis. According to the adaptive-cost hypothesis (Glass & Singer, 1972), the work required to adapt to unpredictable and uncontrollable stressors is substantially greater than that required to adapt to predictable and controllable stimulation. The theory predicts that poorer performance on aftereffects tasks should vary directly with the degree of adaptation, since a greater degree of adaptation implies a greater amount of adaptive effort. Presumably, increased adaptive effort would deplete one's available psychic energies and would thus result in deficits on subsequent demanding tasks.

Information Overload Hypothesis. An alternative form of a psychic cost hypothesis, the information overload hypothesis, has been proposed by Cohen (1978). He argued that unpredictable, uncontrollable stressors, because they are potentially threatening, substantially increase demands on attentional capacity. This increased demand might occur because individuals are required to monitor threatening stimuli to decide how to respond, or because effort is required to tune out distracting stimuli. Prolonged exposure to an environmental stressor and/or to a high information load should result in cognitive fatigue -- an insufficient reserve of attention to perform demanding tasks.

Learned Helplessness Theory. Learned helplessness theory was proposed by Seligman (1975) to explain the locus of control concept. He argued that subjects who are unable to predict and control a stressor learn that their reinforcements are independent of their responses, which results in motivational decrements that are manifested in poorer performance. In other words, individuals submit to negative consequences because their experiences have demonstrated that any action to avoid them is futile.

Locus of Control. The personality trait of locus of control (Rotter, 1966) involves the degree to which individuals perceive that they have control over events occurring in their lives. According to the theory, an individual with an external locus of control perceives that circumstances, bad or good luck, other people, or events are responsible for what occurs in life while an individual with an internal locus of control perceives that individuals are the makers of their own destinies and responsible for their own fortunes or misfortunes. Internality increases with age, and women in general are more externally oriented according to the research (Lefcourt, 1981).

Locus of control has been shown to be a moderator of stressful life events, life events having a more severe impact on externals (Lefcourt, 1981). Internals seem to demonstrate a resistance to stress, the trait found by Zaraycka (1982) to be a predictor of accidents. Internals are also reported to be more resistant to illness and there is a consistent and statistically significant finding that externals report more anxiety than internals. The impact of locus of control on stressful occupational events is illustrated by a study of manager's behavior after a flood (Anderson, 1977). Internally oriented managers responded in a more task-oriented way, demonstrating less stress while externals responded with anger, anxiety, and hostility.

Since stress and anxiety have been reported to contribute to error and accidents, and locus of control has been shown to moderate stress and anxiety, it follows that locus of control is an important variable in errors and accidents. Only one study was found which focussed on this relationship directly, finding no significant difference in Rotter's locus of control scores between two work groups with differing accident rates (Sims, Graves, & Simpson, 1984). However, the volunteer miners used as subjects in this study were reported to be significantly higher on internal locus of control measures than a comparison sample of university students.

stress and other related variables were not examined in this study. Since predictability and controllability have been shown to be important aspects of physical stressors and their relationship to error, it is likely that locus of control will prove to be an important moderator variable in the relationship of social stress to error.

Proposed Model

The variables discussed in the previous section can be combined to develop a model of the psychosocial variables related to occupational accidents. This section includes a discussion of the direct and indirect relationships proposed between safety management, experience, danger level, physical hazards and stressors, life stress, locus of control, and anxiety with occupational accidents.

The theoretical model presented in Figure 1 illustrates the proposed relationship between the aforementioned variables. The model combines the findings from the literature into an integrative theory. Research supports the propositions that physical hazards, danger level, experience, safety management, and anxiety affect accidents directly. This study will attempt to validate these findings.

Research also supports the proposition that stress, anxiety, and locus of control are interrelated: Stress

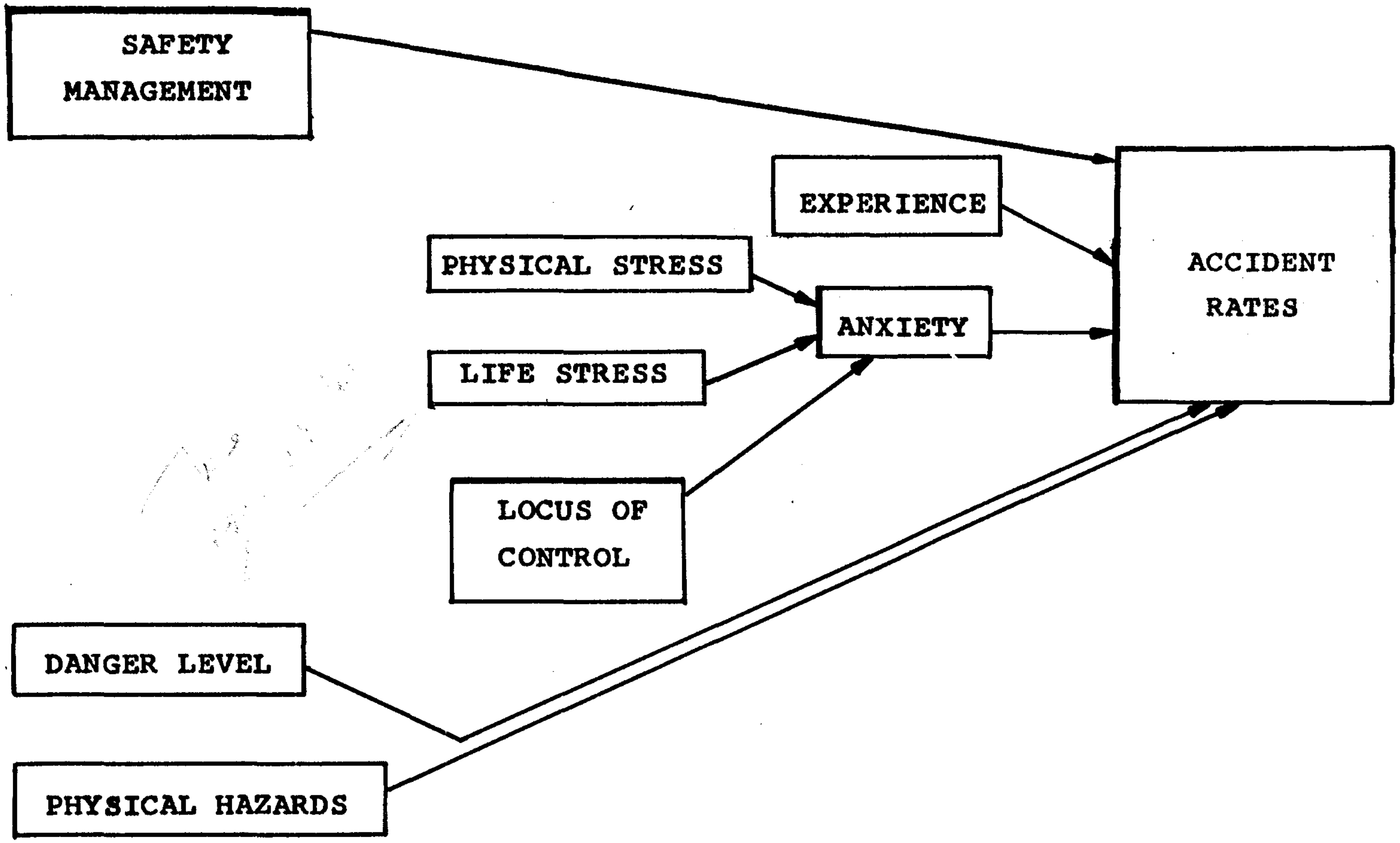

Figure 1. Proposed model of the variables related to accidents.

leads to anxiety and locus of control moderates the amount of anxiety a person may feel in response to this stress. Stress and locus of control, then, are proposed to relate to accidents only through their effect on anxiety.

Studies on social stress and anxiety as they relate to accidents are all post-dictive in nature. The procedure in these studies was to interview individuals who were involved in accidents to determine their stress and anxiety levels before the accident occurred. This study, however, will measure group levels of social stress, anxiety and accidents concurrently in order to develop an equation relating these variables to accidents.

Perceived uncontrollability of physical stressors has been shown to affect performance adversely. As suggested in the adaptive-cost hypothesis (Glass & Singer, 1972), perhaps an individual's energy is drained due to the greater adaptive effort necessary to maintain the same performance level and so safety precautions suffer. As explained by the information overload hypothesis (Cohen, 1980), perhaps an individual's channel capacity becomes overloaded and secondary tasks such as safety precautions suffer as a result of this overload. Lastly, perhaps individuals learn that their reinforcements are independent of their efforts and the motivation to attend to safety is diminished as suggested by learned helplessness theory (Seligman, 1975). This study will investigate the effect of uncontrollable physical stressors on accidents. It is proposed that physical and life stressors will affect accidents indirectly by increasing anxiety.

Only one study has examined the direct relationship between accidents and locus of control. The literature supports the hypothesis that locus of control moderates the impact of stressful life events and physical stressors on individuals. Since anxiety leads to accidents, the hypothesis that locus of control leads to accidents through its effect on anxiety (i.e., by moderating stress) will also be tested in this study.

CHAPTER III

METHOD

This chapter on methodology begins with a discussion of the independent and dependent variables investigated in the study. Descriptions of the subjects and instruments used in the study are given next. The chapter concludes with a discussion of the procedure followed and analyses performed in the study.

Variables to be Investigated

Data was collected by a survey on the following independent variables: experience, safety management, physical hazards, danger level, physical stressors, social stressors, anxiety, and locus of control.

The dependent measure, group accident rates (number of accidents per 100 man years) during January 1984 to October 1985, was obtained from company accident reports and validated by rates listed on the OSHA-200 forms. A company accident report describing the incident and the apparent causes is completed each time an accident occurs. Monthly, information regarding types and number of accidents is compiled onto the OSHA-200 form which is required by OSHA to keep record of each company's accident history. Accident rates on these forms were calculated according to Occupational Safety and Health Administration policy. An accident is defined as "something that is unplanned, uncontrolled, and in some way undesirable; it disrupts the normal functions of a person or persons and causes injury, death, or near injury" (Anton, 1979). Only those accidents caused at least in part by human error are of interest in this study since psychology is the focus of this research. It was found that all the accidents reported had some component of human error.

Any errors in the reporting of accidents would of course decrease the reliability of the dependent variable thus affecting the statistical conclusion validity of the study. Since the reporting of accidents is an established practice for the company and since accident rates are obtained from two sources, the amount of error in reporting should be small.

In this study, two different measures of accident rates were collected: (1) accident rate per 100 man years for 1985 only and (2) accident rate per 100 man years for 1984 and 1985 combined. This system of accident reporting is used by OSHA. Both measurements of the dependent variable were used in order to obtain a subjective assessment of over how long a period of time accident data needs to be collected in order to achieve reliable indicators. Cohen and Cohen (1975) suggest that rate data undergo log transformation before multiple regressions are conducted upon it. The log transformation of rate data (which is non-linear) linearizes the relationship between the independent variables and accident rate thus capitalizing on the analytic power of multiple regression. Regular accident rates and log of acccident rates were used in the study for this reason.

There were a total of four versions of the dependent variable: accident rate for 1985, accident rate for 1984 and 1985 combined, base-10 logarithm of the accident rate for 1985 , and base-10 logarithm of the accident rate for 1984 and 1985 combined. Correlations between independent variables and accidents were calculated using each of the four versions of the dependent variable. This was done to determine whether or not log transformation would enhance results, and whether data obtained over the most recent six months or most recent one year period would be a better predictor of accident rates. It was found that the log transformation greatly enhanced the predicted relationships and that data collected during both the six month and one year period provided useful information. For these reasons, log of 1985 and log of 1984-1985 combined were used as dependent measures in all subsequent analyses.

Data on work group size was retrieved from company records to further investigate the correlation between group size and accidents since studies on this topic are inconclusive.

Subjects

Subjects were the employees of nine small manufacturing companies: one Chicago area steel sheet metal company, one Chicago area brass sheet metal company, four Milwaukee area steel foundries, one Milwaukee area brass foundry, one Rhode Island brass sheet metal company, and one Racine aluminum and alloy foundry.

Overall, the return rate was 52%. Return rates of each company along with the number of work groups and total number of workers in each company are listed in Table 1. A broad range of response rates was found among the companies (30% to 82%). Analyses of the effect of response rate on the independent and dependent variables revealed no significant effect. Response rate was not correlated with any of the variables used in the study. However, the effect of a possible response bias (nonrespondents differing from respondents) is investigated in the discussion.

Job categories in the sample industries included electrical and mechanical maintenance, trucking,

Table 1

Summary of Company Response Rates

Type of Company	#Groups	Subunit Size	#Returned	Percent
brass mill	3	22	11	50
brass mill	10	62	47	76
steel mill	12	90	74	82
steel foundry	9	125	51	41
steel foundry	11	167	109	65
steel foundry	7	62	22	36
steel foundry	9	146	53	36
brass foundry	9	84	42	50
aluminum foundry	9	86	26	30
Overall	79	854	335	52

clerical, supervisory, operator, and general laborer. The following two job definitions are included to illustrate typical job duties of foundry and sheet metal operators and laborers.

The foundry worker (United States Department of Labor, 1965) performs any combination of the following tasks: melting metal, pouring metal into molds, removing castings from molds, dressing castings, moving foundry materials, and cleaning equipment and work areas. The foundry worker moves sand, castings, flasks or other materials about the foundry by hand, using a wheel-barrow or cart, or by loading them onto a conveyor. Other duties include watering and mixing sand, shoveling sand into flasks, and compacting sand in flasks using a ramming tool. The foundry job involves spraying binder on the surface of sand molds and drying the surface with a blowtorch.

A slitting-machine operator (United States Department of Labor, 1965) is one type of operator in the sheet metal companies. This type of operator sets up and operates a slitting machine to cut sheet metal into strips of specified width. They select, clean, and install spacers and cutters on arbors, and hone cutters with oilstone to remove nicks. Other duties include: pressing buttons to lower the arbor until cutters mesh, measuring clearance with a feeler gage, inserting spacers to adjust spacing to specified tolerance, threading sheets through slitters and verifying dimensions of cut to specifications using a rule.

A range of risk was sampled. Both companies as a whole and work groups within companies varied in their accident rates so there was not a problem with inhibited correlations due to restriction of range of accident rates. For the years of 1984 and 1985 combined, overall company accident rates ranged from 84.5 accidents per 100 man years to 511.8. Across all companies, work groups ranged from a rate of 0.0 accidents per 100 man years to 125.0. There were a total of 79 work groups and 435 employees in the sample. The majority of these subjects were blue collar male, however, 12.2% of the sample were females.

Instrument

The _Employee Assessment of Occupational Hazards_ survey (Guastello, 1984) was used in this study. The survey contained 75 items and took about 25 minutes to complete. Questions 1, 3, and 4, asked about experience: age, years with the company, and years doing similar work. Responses were scaled from 3 to 12 with larger values indicating an older, more experienced person. Information obtained from items 2, 4, and 5 was used for descriptive purposes only. These items concerned: sex, work area, and job category. The rest of the survey was arranged into three major sections: safety, health, and hazard checklist. Response mode for the safety and health questions was kept simple -- agree, do not know, and disagree. To respond to the hazard checklist, the individual merely checked off yes or no depending on if the hazard existed or not.

Safety items included questions on safety management and locus of control.

Safety Management Questions. Safety management questions were as follows:

7. The company safety program really does control accidents.
8. New employees are not properly trained for safety in the work place.
9. The company is concerned with safety in the work place.
10. My co-workers often fail to observe safe procedures in the work place.
11. The place I must work in is usually orderly and tidy.
12. In the place I work, there are usually things all over the floor that people can trip on or hurt themselves on.
13. The company gives us all the safety equipment we need to protect ourselves on the job.
14. There are no safety procedures for some of

the hazards we must work with.

15. People who follow safe procedures are promoted more often than those who do not.

20. When someone is performing a job unsafely, the foreman shows that person how to do the job properly.

21. The foreman usually does not notice when someone is performing a job unsafely.

22. Management requires severe penalties for persons who do not follow safe procedures.

23. Some of this company's safety rules are foolish.

24. People who always follow safety rules are just scared to work here.

25. It is not possible to follow all the safety rules if you want to keep up with production.

Items 7, 9, 11, 13, 15, 20, and 22 were scored as follows: agree=2, I don't know=1, and disagree=0. The "agree" response for these items was favorable to company management, "I don't know" was neither favorable nor unfavorable, and "disagree" was unfavorable. Items 8, 10, 12, 14, 21, 23, 24, and 25 were scored as follows: agree=0, I don't know=1, and disagree=0. For these items, the "agree" response was unfavorable to company management, "I don't know" was again neither favorable nor unfavorable, and "disagree" was favorable. The subscale was scored 0-30 where larger values indicated the relative adequacy of the companies' policies and procedures. These items were modeled after factors found to discriminate between high and low risk groups in studies of Zohar (1980) and Smith et al.(1978).

Locus of Control Questions. The other safety items, locus of control, were as follows:

26. Accidents are caused by mistakes people make.
27. Sometimes accidents just happen, and there is nothing that can be done about it.
28. Trusting in luck does not work to improve safety.
29. "Near-miss" accidents are not important, only the ones that actually happened.
30. I do not have much control over whether the people I work with follow safe procedures.
31. I feel I have been lucky with regard to accidents.
32. I feel I can always keep myself out of an accident.
33. Accidents have nothing to do with luck.

The responses for items 26, 28, 32, and 33 were coded in the following manner: agree=0, I don't know=1, and disagree=2. Internal locus of control individuals were expected to answer "agree" to these items more often, while external locus of control individuals were expected to answer "disagree." Items 27, 29, 30, and 31 were reverse scored so that internally controlled respondents would tend to disagree while externally controlled respondents would tend to agree. The subscale was scored 0-16 where resulting scores represented the degree to which the employee was externally controlled with respect to accidents. After conducting a reliability analysis of this scale, item 26 was eliminated from the scale (see Results). The range of scores was reduced from 0-16 to 0-14 as a result of this procedure.

It should be mentioned that prior to including this scale in the survey, a pilot test was conducted on the scale using a sample of 184 students from a Midwestern University (Guastello & Guastello, in press). This locus of control scale was found to be significantly correlated with the Rotter locus of control scale (r=.13, p<.05). However, this is less than 2% of shared variance. Nevertheless, the scale was included due to the need for a short scale with face validity (see Procedure). The implications of this low correlation for the locus of control construct are elaborated upon in the discussion.

Health questions consisted of: (1) anxiety questions from the Taylor Manifest Anxiety Scale (1953); and (2) the life stress checklist from the Holmes and

Rahe (1967) scale.

<u>Anxiety Questions.</u> Anxiety questions were as follows:

36. I am extremely tired when I get home from work every day.
37. I am often sick to my stomach.
38. I am more nervous than other people I work with.
39. I have at least one bad headache a week.
40. I work under a great deal of tension.
41. I can feel my hands, arms, or legs shaking when I work.
42. I have nightmares about my job.
43. I do not sweat more than other people.
44. Most people are more afraid of the job hazards than I am.
45. I am often hungry between meals.
46. I do not have problems with diarrhea or constipation.
47. I am very sure of myself in new situations.

Items 36, 37, 38, 39, 40, 41, 42, and 45 were scored as follows: agree=2, I don't know=1, and disagree=0. Higher anxiety individuals were expected to agree with most of these items. Higher anxiety respondents were expected to disagree with items 43, 44, 46, and 47 which were reverse scored. The subscale was scored 0-22.

Higher values indicated higher anxiety. After reliability analyses were conducted, items 44 and 47 were eliminated from the scale (details in Results). Scoring changed from 0-22 to 0-18 as a result of this procedure.

Life Stress Checklist. Also included in the health area of the survey was the life stress checklist which included the following items:

48. My wife/husband has died within the last six months.
49. A close family member (not husband or wife) has died within the last six months.
50. A close friend has died within the last six months.
51. I am in the process of obtaining a divorce.
52. I feel my job security has improved in the last six months.
53. I have been given new job assignments in the last six months.
54. I am now making plans for retirement.
55. My working hours have changed recently.
56. Lately I have been sleeping less or at different hours.
57. I have been eating less regularly lately.
58. Someone in my family has suffered a major illness or injury.

Although the "I don't know" responses were not expected for items 48-51, the option was retained so that the response format would be consistent throughout the scale. The following coding scheme was used for all items in the scale: agree=2, I don't know=1, and disagree=0. Resulting scores ranged from 0-22 where larger values indicated the presence of more stressful life events than smaller values.

Questions about the working environment included questions about the danger level of the environment and a physical stressor and physical hazard checklist.

Danger Level. Questions used to determine the level of danger in the plant were as follows:

16. There are no real hazards in my work area.
17. People in my work place are often injured enough to need help from the clinic.
18. Accidents in my work place sometimes put people out of work for a long time.
19. People in my work place are sometimes killed on the job.
34. There are no real health hazards in my work place.
35. People in my work place are sometimes sick due to health hazards on the job.

Responses to items 17, 18, 19, and 35 were coded as follows: agree=2, I don't know=1, and disagree=0. Items 16, and 34 were reverse scored. The subscale scores ranged from 0-12 where higher numbers indicated a more dangerous work environment than lower numbers.

<u>Stress and Hazard Checklist</u>. The stressor and hazard checklists were derived from actual hazard reports of various manufacturing companies. The response format for both checklists was yes/no. "Yes" was coded as 1 and "No" was coded as 0. The physical stressors checklist contained these items: crowding with other people (item 60), work place too hot (item 64), work place too cold (item 65), too much dust (item 66), toxic fumes (item 67), not enough light (item 71), intense noise (item 72), and on an irregular shift (item 75).

The response choice of "shift you are working" varied with each company because companies had different ways of dividing up the work day. In any case, if an individual worked the first shift he or she was assigned a 1 and if he or she worked any other shift (including rotating shift), he or she was assigned a 0 code. This code was then added to the physical stress score. Items were scored 0-8 where higher numbers meant that more stressors were present.

The physical hazard checklist consisted of the following items: walkways crowded with equipment (item 59), broken tools (item 61), trash in work space (item 62), missing safety devices (item 63), equipment not properly stored (item 68), open fires (item 69), explosions (item 70), sometimes cannot hear warning signals (item 73), and people who do not work here walking through dangerous places (item 74). Items were scored from 0-9 where higher numbers meant that more hazards were present in the work environment.

Procedure

The survey method was chosen because of its suitability for the purposes of the study. The survey was administered on company time because this was the easiest way to contact subjects and it helped to achieve a response rate greater than one that would be achieved by mail. The companies had only two conditions for administering the survey on company time. First of all, the length of the administration time could be only about 1/2 hour. Secondly, the survey had to have face validity. Safety directors wanted to see that the questions were related to accidents. Safety managers were not favorable to experimental designs due to the time experiments take and due to their lack of face validity (as perceived by non-researchers).

The surveying began in August. The safety manager of each company was responsible for administering the survey to their employees. The surveys were accompanied by a cover letter from the experimenter although there was phone communication prior to this. The cover letter covered the following key points:

1. Thank you for agreeing to participate in this research project.

2. The goals of the project are to study psychological variables that can greatly influence accident rates and in this way to aid in the development of new control strategies. You will of course receive a copy of all reports resulting from this research.

3. No individual data can or will be exposed. There will be no ranking or rating of individuals since this would be against union contract.

4. Employee participation is voluntary but strongly encouraged.

5. Please instruct one employee in each work group to collect surveys (folded over and stapled) and to return them to the safety director who will mail them to the researcher.

The safety director of each company was requested to include copies of accident reports, OSHA-200 forms, and work group sizes when returning the surveys. All data was returned by October.

Analyses

Factor Analysis. A factor analysis was performed using individual level data to determine the factor structure of the survey. Cronbach's alpha was calculated to determine the reliability of each of the factors. For these analyses, n=435. Eight factors as described under the instrument section were expected (i.e., locus of control, danger level, life stressors, physical stressors, anxiety, safety management, physical hazards, and experience).

Path Analysis. Path analysis was the most appropriate statistical technique for analyzing the data in an attempt to validate the proposed model (Pedhazur, 1982). It was important to use group accident rates as the dependent variable since a person' s involvement in an accident did not necessarily mean that the person caused the accident. Since group accident rates were used, group means on the independent variables proposed to directly relate to accident rate also had to be used so that the levels of analyses were comparable.

The path analysis produced a path coefficient for each proposed relationship between variables in the model. The analysis was basically comprised of two multiple regressions. The first used group level data to predict accident rates from safety management, physical hazards, danger level, experience, and anxiety. The second used individual level data to predict anxiety from locus of control, physical stressors, and social stressors. Individual level data was more appropriate for variables such as anxiety, locus of control, and life stress since differences in these variables were all measured at the individual level. Also, using individual level data when possible, increased n from 79 to 435.

An overall multiple regression was also conducted (using group level data for all eight variables) to determine how each factor directly related to accidents. The coefficient of determination, R^2, obtained from this regression indicated the proportion of variance in accident rates accounted for by the entire combination of psychosocial variables.

A cross-validation (Cohen & Cohen, 1975) was performed on the path analysis regression equations. After analyses on the intact sample was completed, the sample was divided into 2/3 and 1/3 parts. The analyses were then repeated on the larger part to obtain regression weights. These weights were then applied to the smaller partial sample to obtain predicted values of the dependent variables to correlate with the actual values of the dependent variables. These correlations provided a measure of the accuracy of the original weights.

CHAPTER IV

RESULTS

This chapter is a report of the results of the analyses performed on the data obtained in the study. The findings are discussed in the following order: factor analysis, reliability analysis, correlations between survey variables, correlations of survey variables with accidents, subunit size, path analysis, overall regression, and cross-validation.

Factor Analysis

A factor analysis, using the principal axis method, was performed on the survey variables. The varimax rotation converged in 31 iterations and 11 factors with eigenvalues>.90 (see Table 2) were extracted. Loading criterion was set at 0.30. It was hypothesized that each of the eight scales on the survey would emerge as a distinct factor in the analysis. Results approximated this expectation.

Factor 1, a messiness factor, was composed of four physical hazards items (items 59,61,62, and 63) and two safety management items (items 11, and 12). It appears

Table 2

Factor Analysis of Survey Variable (Questions 1,3,4,7-75)

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
Q1	-0.04232	-0.04198	-0.02351	.74442	.03436
Q3	- .04603	.01356	.07963	.76968	-0.07731
Q4	.00467	.05082	.00140	.70066	.04344
Q7	-0.19512	-0.05565	-0.11232	-0.03049	.45924
Q8	-0.11653	-0.16105	-0.05641	-0.02055	-0.02569
Q9	-0.21294	-0.13702	-0.12754	-0.03556	.63111
Q10	-0.16286	-0.08886	-0.02145	-0.07314	.12684
Q11	-0.47088	-0.10792	-0.05390	.07107	.24327
Q12	-0.54427	-0.10479	-0.12957	-0.00367	.22033
Q13	-0.14409	-0.12056	-0.05725	.03060	.47190
Q14	-0.18615	-0.08916	-0.12355	.02343	.24982
Q15	-0.03046	-0.13840	.02272	-0.01889	.12188
Q16	.14433	.05711	.03684	-0.03813	-0.09295
Q17	.07749	.24764	.06631	.03887	-0.11086
Q18	.06858	.06139	.04917	.02987	-0.03804
Q19	.09929	-0.05350	.01881	.05613	.02840
Q20	-0.28307	-0.16603	-0.01311	-0.04591	.39728
Q21	-0.25749	-0.18378	-0.01089	-0.07667	.19563
Q22	-0.11484	-0.10083	-0.03108	.00149	.30491
Q23	-0.23655	-0.05881	-0.06089	.01760	.12377
Q24	-0.18665	.03920	-0.13368	-0.05496	.10724
Q25	-0.17431	-0.10801	-0.20993	-0.01345	.16666
Q26	-0.04570	-0.00703	.00183	.06371	.31964
Q27	.06667	.02303	-0.07137	.09137	.03837
Q28	-0.02739	.03594	.01123	-0.04328	.02195
Q29	-0.10028	.09002	-0.03693	.02532	.00148
Q30	-0.10306	-0.20883	.00985	.01977	.17870
Q31	.14827	.07641	.06456	.02078	.00401
Q32	-0.01433	.01655	-0.10016	-0.04164	.18967
Q33	-0.00786	-0.01753	-0.02548	-0.00831	-0.01038
Q34	.11926	.22072	.08648	-0.03541	-0.07889
Q35	.26433	.17423	.20036	.11469	-0.07134
Q36	.10521	.26584	.52755	-0.03567	-0.14625
Q37	.08150	.10724	.50961	-0.05432	-0.09588

Table 2

continued

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
Q38	.06940	.02983	.47358	.01823	.03997
Q39	.08848	.02612	.54526	-0.02419	-0.10893
Q40	.11561	.05162	.54058	.18396	-0.04361
Q41	.07685	.10544	.38784	.03803	.03369
Q42	.05136	.09793	.47091	-0.02004	-0.02633
Q43	-0.01252	-0.00366	.02248	-0.04891	-0.00433
Q44	.03427	.12550	.18482	.00640	.03973
Q45	.07027	.11147	.21798	-0.13739	-0.03167
Q46	-0.05082	.10153	.07094	.03370	.00098
Q47	-0.03155	-0.02062	.03805	-0.03212	.03140
Q48	.02569	-0.01347	.06869	.08347	-0.04955
Q49	.00471	-0.00309	.06562	.02746	-0.03285
Q50	.09246	.06172	.05687	.09019	-0.03261
Q51	.04648	.07118	.01637	.05988	-0.02779
Q52	-0.13834	-0.16355	-0.16464	-0.22522	.12424
Q53	.04363	.01786	.03644	-0.08260	.01872
Q54	.00885	-0.05191	-0.03781	.29558	.01411
Q55	.02535	.10112	.05299	.00534	-0.01004
Q56	.06618	.02371	.13066	-0.10349	.02528
Q57	.09612	.05126	.16320	-0.10422	-0.08160
Q58	.14524	.11391	.07537	-0.03789	-0.01580
Q59	.60539	.13088	.19254	.05788	-0.03295
Q60	.29018	.04975	.17036	-0.03741	-0.06762
Q61	.43962	.14501	.11165	-0.05165	-0.10406
Q62	.59459	.23373	.10817	.00729	-0.10956
Q63	.34888	.18374	.05581	.08663	-0.15517
Q64	.16107	.58558	.09972	-0.05868	-0.09234
Q65	.24642	.46608	.19565	.16944	-0.06795
Q66	.20364	.56781	.13016	.02710	-0.14209
Q67	.20679	.35141	.14553	.09774	-0.11916
Q68	.45422	.16802	.04064	-0.00009	-0.15427
Q69	.11181	.29145	.03720	-0.07022	-0.05990
Q70	.09674	.09550	.04600	.08828	-0.02509
Q71	.19874	.34486	.08237	.02194	-0.11282
Q72	.07933	.64030	.08630	-0.03501	-0.00798
Q73	.19065	.34709	.03158	.11019	-0.19158
Q74	.23342	.24000	.17613	.12792	-0.09622
Q75	.03163	.01029	.07000	-0.15455	-0.08466
EIGENVALUE	8.86139	2.38065	2.28558	1.72022	1.47612
PCT OF VAR	12.3	3.3	3.2	2.4	2.1

Table 2

continued

	FACTOR 6	FACTOR 7	FACTOR 8	FACTOR 9	FACTOR 10	FACTOR 11
Q1	-0.01978	.06658	-0.17205	.06185	-0.10260	-0.00240
Q3	.03284	.01501	.02971	.02141	-0.03359	-0.01219
Q4	.06572	.05888	.06409	.02210	-0.05496	-0.05706
Q7	-0.16240	-0.01348	-0.04347	-0.03050	.04074	-0.04826
Q8	-0.02575	.06513	-0.03747	-0.06160	-0.00810	.02282
Q9	-0.00167	.13820	-0.04363	-0.03036	-0.04694	.00882
Q10	-0.03822	.06904	-0.08214	.00228	-0.00335	-0.07480
Q11	-0.02996	.09393	-0.01960	.04348	-0.00043	.10210
Q12	-0.11645	.07170	-0.00075	.00451	-0.05631	.10786
Q13	-0.04849	.11511	-0.17371	-0.07657	-0.01474	-0.00996
Q14	-0.06131	.24188	-0.10908	.09714	-0.02828	.01785
Q15	.07820	.02261	-0.05878	-0.03895	-0.03751	.02704
Q16	.07335	.04682	.63156	-0.01219	.01898	.02996
Q17	.59082	.01601	.07144	.01401	-0.02119	.00074
Q18	.12952	.71295	-0.05776	.07120	.05799	.04241
Q19	-0.05659	.45884	-0.15875	.13213	-0.10522	.09513
Q20	-0.06993	-0.12383	-0.01312	.02479	.01948	-0.03366
Q21	-0.06364	-0.07867	.06668	.01564	-0.08176	.05256
Q22	-0.16285	.06211	-0.02881	.19685	-0.06874	.02444
Q23	-0.06674	-0.03001	.42549	-0.10051	-0.11481	.03280
Q24	-0.03862	-0.15943	.08065	-0.12578	-0.08224	.10762
Q25	-0.10133	.09767	.35155	-0.03664	-0.04696	.13068
Q26	-0.03358	.04469	.14975	-0.04793	.04920	.07730
Q27	.09118	-0.02430	.44339	-0.02410	.00793	.11232
Q28	.05389	.04158	.04834	-0.00894	.04352	.68034
Q29	.24523	-0.07029	.13260	-0.03536	.14262	.42350
Q30	.09316	-0.15344	.48549	-0.00745	.05371	-0.06732
Q31	-0.08281	.04846	-0.28990	.06849	.06721	.04635
Q32	-0.26628	-0.05886	-0.02075	-0.03337	.03172	-0.00037
Q33	-0.03222	.10265	-0.01445	.05074	-0.02296	.32468
Q34	.63512	.09547	.06038	-0.01766	-0.06090	.10537
Q35	.21179	.28909	-0.17719	.01391	-0.01643	-0.03426
Q36	-0.02624	.05915	-0.17972	-0.01907	.06490	-0.04851
Q37	.03622	.01486	-0.07928	.06348	-0.04010	-0.01098

Table 2

continued

	FACTOR 6	FACTOR 7	FACTOR 8	FACTOR 9	FACTOR 10	FACTOR 11
Q38	-0.05100	-0.00900	.01272	.01710	-0.16379	.01672
Q39	-0.02500	-0.10117	.12138	.06001	.09374	.00106
Q40	.12848	-0.00042	.09412	.00397	.09717	.02075
Q41	.17004	-0.07387	-0.04918	.08090	.11962	-0.15177
Q42	.05456	.00117	-0.10674	.03395	.31278	-0.01508
Q43	-0.04407	-0.00441	-0.01536	.03538	.01758	-0.10388
Q44	.05915	-0.17497	.05007	.03944	.00931	-0.05342
Q45	.03263	-0.35315	.05768	.12180	.10683	.06464
Q46	-0.01367	.04369	-0.00682	-0.07082	-0.11020	-0.30914
Q47	-0.00038	.02284	-0.10496	-0.01668	.00430	-0.05917
Q48	-0.09684	-0.09996	-0.08807	.22487	-0.03630	.05769
Q49	.04310	-0.02200	-0.01820	.63317	.06376	-0.02235
Q50	.09035	-0.13061	.00132	.75008	.01030	.04603
Q51	-0.00951	.04069	-0.01162	-0.01156	.06203	-0.12450
Q52	-0.05032	.02863	-0.00023	.07758	.06143	-0.07495
Q53	-0.06657	.09623	-0.03082	.01146	.50195	.07401
Q54	.02573	.09655	-0.06662	.18848	.19375	.04291
Q55	.01959	-0.21460	.00305	.02615	.49593	.01990
Q56	.13242	-0.22797	.12876	.11077	.44267	.04243
Q57	.03689	-0.02200	.01539	.00033	.22361	-0.01332
Q58	.03299	-0.01696	.07795	.25406	-0.09215	.01154
Q59	.09138	-0.04273	.13237	.06610	.08117	.03672
Q60	.10948	.01882	.01635	.10870	.01123	.07972
Q61	.08116	-0.12737	.13379	-0.01486	.05926	.15943
Q62	-0.06137	-0.10214	.05299	.05898	-0.00026	.00295
Q63	.17352	-0.05244	.14880	-0.05477	.05151	-0.01330
Q64	.05502	-0.06598	.05782	.06212	.01432	-0.07978
Q65	.10879	-0.04349	-0.09096	.12836	.03701	.07562
Q66	.06652	-0.04763	.13602	-0.10295	.11823	.04679
Q67	.18548	-0.20812	.10493	.06696	-0.03750	.04600
Q68	.05893	.02510	.12884	.08624	-0.00729	-0.07104
Q69	-0.01827	.01191	.08920	-0.03331	.10846	.06212
Q70	.10235	-0.07253	.04411	.01331	-0.02564	-0.00664
Q71	.08924	.01408	.03489	.01077	-0.02369	-0.05324
Q72	.03055	-0.10859	.14984	.00813	.01785	.04507
Q73	.10181	-0.07538	.00849	.01417	.08784	-0.11356
Q74	.15049	-0.06284	.06055	.12094	.14235	.08897
Q75	.00556	-0.08348	-0.03544	.03308	.30487	-0.01996
EIGEN-VALUE	1.35591	1.22668	1.12579	1.06636	1.00241	.92546
PCT OF VAR	1.9	1.7	1.6	1.5	1.4	1.3

that this factor represents a construct of tidiness in the work area and company.

Factor 2, a physical stress factor, was defined by all the physical stress items (items 64,65,66,67,71, and 72) except crowding and shiftwork. Item 73, warning signals not heard, which had been proposed as a physical hazard loaded on this factor also. This was probably due to its direct relationship to the physical stressor, noise.

Factor 3, an anxiety factor, was composed of a majority of the anxiety items (items 36,37,38,39,40,41, and 42). Factor 4, the demographic factor, was composed of the three demographic items (items 1,3, and 4). Factor 5, a management control factor, was defined by several safety management items (items 7,9,13,20, and 22) and one locus of control item (item 26). This factor appears to represent a construct of "safety management in control of accidents."

Factor 6, a danger level factor, was composed of three items (items 17,18, and 19) that determine the extent of injuries in the work area. Factor 8, also a danger level factor, was composed of two items (items 16, and 34) that determine whether or not danger exists at all. It appears that the danger level items form two constructs of danger that are divided according to level of danger they are measuring.

Factor 7 was composed of two safety management items (items 14, and 23), two locus of control items (items 27, and 30) and one anxiety item (item 45). This factor is basically uninterpretable. Factor 9 was defined by death of a relative, and death of a close friend which were both life stress items (items 49, and 50).

Factor 10, shiftwork factor, was composed of one anxiety item (item 10), three life stress items (items 53,55, and 56) and one physical stress item (item 75). All of these items concern shiftwork with its associated impact on stress and anxiety.

Factor 11, a locus of control factor, was composed of three locus of control items (items 27,28, and 33) and one anxiety item (item 46). This factor represents beliefs about accident control and one anxiety item which correlates with locus of control.

The response format was agree, do not know, and disagree throughout the survey with the exception of the physical hazard and stress checklists for which it was yes/no. Therefore, it is unlikely that the results of the factor analysis were due to any response variance error. However, the results could have been affected by contingency errors. Items forming an expected factor were often presented consecutively in the survey thus inflating the chances of finding these expected factors in the factor analysis. If this error was severe,

Table 3

Reliability Analysis of Survey Factors

Survey Factor	Cronbach's Alpha	#Items
Safety Management	.782	15
Physical Hazards	.746	9
Danger Level	.644	6
Experience	.694	3
Physical Stress	.694	8
Anxiety	.642	10
Life Stress	.504	11
Locus of Control	.335	7

however, the expected factors would have been more strongly supported than they were.

The implications of these results for the proposed model are discussed in the following chapter.

Reliability Analyses

Reliability analyses of the eight scales in the survey basically produced the expected results (see Table 3). Values of Cronbach's alpha ranged from .64-.78 for: safety management, physical hazards, danger level, experience, physical stressors, and anxiety. Two items were removed from the anxiety scale to increase alpha by .10. Item 44, "Most people are more afraid of the job hazards than I am," perhaps should have been stated as "I am more afraid of the job hazards than most people." In the original form, the determination of irrational fear (a symptom of anxiety) which is the objective of this item is not accomplished. A person who is not anxious could disagree with this statement as easily as a highly anxious person. However, with the revised item, it is more likely that only the highly anxious respondents could agree.

The second item removed from the anxiety scale to enhance reliability was item 47, "I am very sure of myself in new situations." It is likely that this item tapped a different personality characteristic, such as self-confidence rather than anxiety. While it is true that anxious people may be very unsure of themselves in new situations, people who are not generally anxious could feel the same way.

One item was eliminated from the locus of control scale to increase alpha by .10. Upon examination, it was discovered that the item, "I feel I have been lucky with regard to accidents," did not differentiate internal from external locus of control respondents very well. An internally oriented employee could agree with this statement as easily as an externally oriented one. Even with this correction, the locus of control scale obtained a low reliability as did the life stress scale. This problem is discussed further in Chapter IV.

In summary, alpha values on the whole were adequate although they could have been better. Several items which were found to be flawed were eliminated.

Correlations between Survey Variables

Pearson correlation coefficients were computed to obtain the interrelationships between all the survey variables (Table 4). The correlations were based on individual level data and were in logical directions. Safety management, danger level, physical hazards, physical stressors, anxiety, life stressors and locus of control were all significantly correlated with each other except locus of control was not correlated with life stress. A manufacturing plant with a good safety

Table 4

Correlation Matrix of the Survey Variables

\- - - - - - - - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - -

	SAFETY	ANXIETY	DANGER	LOCUS	EXP3	HAZLIST	PSTRESS	STRESSUW
SAFETY	1.0000	-0.3455	-0.3899	.3300	.0044	-0.6044	-0.5510	-0.1665
	(0)	(432)	(432)	(432)	(406)	(423)	(418)	(430)
	P= .	P= .000	P= .000	P= .000	P= .464	P= .000	P= .000	P= .000
ANXIETY	-0.3455	1.0000	.2434	-0.2339	-0.0460	.3674	.3989	.2494
	(432)	(0)	(433)	(433)	(407)	(424)	(419)	(431)
	P= .000	P= .	P= .000	P= .000	P= .177	P= .000	P= .000	P= .000
DANGER	-0.3899	.2434	1.0000	-0.1193	.0233	.4562	.4307	.1364
	(432)	(433)	(0)	(433)	(407)	(424)	(419)	(431)
	P= .000	P= .000	P= .	P= .006	P= .320	P= .000	P= .000	P= .002
LOCUS	.3300	-0.2339	-0.1193	1.0000	.0368	-0.1817	-0.1663	-0.0074
	(432)	(433)	(433)	(0)	(407)	(424)	(419)	(431)
	P= .000	P= .000	P= .006	P= .	P= .230	P= .000	P= .000	P= .440
EXP3	.0044	-0.0460	.0233	.0368	1.0000	.0145	-0.0253	-0.1127
	(406)	(407)	(407)	(407)	(0)	(401)	(396)	(405)
	P= .464	P= .177	P= .320	P= .230	P= .	P= .386	P= .308	P= .012
HAZLIST	-0.6044	.3674	.4562	-0.1817	.0145	1.0000	.6590	.2395
	(423)	(424)	(424)	(424)	(401)	(0)	(417)	(422)
	P= .000	P= .000	P= .000	P= .000	P= .386	P= .	P= .000	P= .000
PSTRESS	-0.5510	.3989	.4307	-0.1663	-0.0253	.6590	1.0000	.2459
	(418)	(419)	(419)	(419)	(396)	(417)	(0)	(418)
	P= .000	P= .000	P= .000	P= .000	P= .308	P= .000	P= .	P= .000
STRESSUW	-0.1665	.2494	.1364	-0.0074	-0.1127	.2395	.2459	1.0000
	(430)	(431)	(431)	(431)	(405)	(422)	(418)	(0)
	P= .000	P= .000	P= .002	P= .440	P= .012	P= .000	P= .000	P= .

(COEFFICIENT / (CASES) / 1-TAILED SIG)   " . " IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED

EXP3=experience HAZLIST=physical hazards PSTRESS=physical stress
STRESSUW=life stress

program, according to these results, would also likely have low levels of danger, physical hazards, physical stressors, anxiety, life stress and an internal locus of control bias.

Age and experience were significantly correlated with life stress. The more experienced employees reported less life stress, perhaps since the commonly cited stressors included new job assignments, new work schedules, and less job security.

Correlations of Survey Variables with Accidents

A matrix of Pearson product-moment correlations was computed to obtain the relationships between the survey variables with the dependent measures of accident rate. The correlations were based on group level data and the obtained correlations were those predicted by the proposed model (see Table 5). The log transformation of accident rates greatly enhanced the obtained correlations. Without the transformation, only four significant correlations were found. In subsequent analysis, therefore, the log of accident rates was used as the the dependent measure.

Safety management, danger level, physical stress, experience, and locus of control were all significantly correlated with the log of accident rates for 1985 and 1984 combined. Accident rates were lower for plants with good safety management, lower levels of danger and

Table 5

Correlation Matrix of Survey Variables with Accident Rates

	AR85	POOLAR	LAR	LPOOLAR
SAFETY	-0.1242	-0.1298	-0.2390	-0.2108
	(79)	(79)	(79)	(79)
	P= .138	P= .127	P= .017	P= .031
DANGER	.0913	.2208	.2293	.2855
	(79)	(79)	(79)	(79)
	P= .212	P= .025	P= .021	P= .005
ANXIETY	.1836	.0317	.2481	.0991
	(79)	(79)	(79)	(79)
	P= .053	P= .391	P= .014	P= .192
EXP3	-0.1082	-0.1091	-0.1984	-0.1936
	(78)	(78)	(78)	(78)
	P= .173	P= .171	P= .041	P= .045
PHAZ	.0381	-0.0070	.1245	.0295
	(79)	(79)	(79)	(79)
	P= .370	P= .475	P= .137	P= .398
PSTRESS	.1825	.1108	.3271	.2161
	(79)	(79)	(79)	(79)
	P= .054	P= .165	P= .002	P= .028
UWSTRESS	.0653	-0.0090	.0562	.0992
	(79)	(79)	(79)	(79)
	P= .284	P= .469	P= .311	P= .192
LOCUS	-0.0927	-0.2450	-0.1794	-0.2642
	(79)	(79)	(79)	(79)
	P= .208	P= .015	P= .057	P= .009

(COEFFICIENT / (CASES) / 1-TAILED SIG)

EXP3=experience PHAZ=physical hazards
PSTRESS=physical stress UWSTRESS=life stress

AR85=accident rates for 1985
POOLAR=accident rates for 1984 and 1985
LAR=log of accident rates for 1985
LPOOLAR=log of accident rates for 1985 and 1985

physical stress. Accident rates were also lower for more experienced workers and for internal locus of control individuals.

The use of the log of accident rates for 1985 only yielded the same results with one additional finding. Anxiety was significantly correlated with 1985 accidents, where less anxious departments had fewer accidents. A recency effect appeared to be occurring in which anxiety predicted accidents that were close in time to the reports of the anxiety. The 1984-1985 pooled data was likely to be more reliable with respect to the remainder of the proposed model, thus the log of 1984-1985 accident rates was retained for use as a dependent measure.

Subunit Size

Work group size was correlated with the four measures of accident rate. A significant positive correlation (r=.21, p<.04, n=79) was found only between size of the work group and log of accident rate for 1985. There was no correlation between the log of the pooled 1984-1985 accident rates and work group size. This lack of correlation could be attributed to fluctuations in group size from 1984 to 1985; only sizes for 1985 could be obtained for the analysis.

Both linear and curvilinear model components were tested in the regression analysis. Size and size-squared were regressed upon log of accident rate of 1985. The linear effect accounted for 4.1% of the explained variance in the dependent variable ($p<.073$) , which increased to 8.6% when the quadratic was added ($p<.033$). Results supported a curvilinear hypothesis.

A scattergram revealed a break-point relationship which integrated the findings of a linear and a curvilinear relationship. Size and accidents were positively correlated in a linear fashion until a breakpoint at about 15 people where only large accident rates occurred. The distribution for small groups appeared to be bimodal, with a lower mode at accident rate=0.00, and an upper mode at accident rate=0.90-2.23. When size became greater than 15 people, the distribution at accident rate=0.00 disappeared and only the higher accident rate distribution remained.

Path Analysis

A path analysis consisting basically of two multiple regressions was conducted to test the model. The forced entry method of multiple regression was used since this is the appropriate method for testing models (Cohen & Cohen, 1975). The first multiple regression used accident rate as the dependent variable. The independent variables which were proposed to relate directly to accident rate were entered at the group level in the following order: safety management, danger level, experience, anxiety, and physical hazards. When regressed upon the log of accident rates for 1985 only, the variables were found to account for 15.7% of the variance which was significant at the $p<.05$ level (see Table 6). When the variables were regressed upon the log of accident rates for 1984 and 1985 combined, the variance accounted for was 15.3% which was significant at the $p<.005$ level (see Table 7).

The second regression in the path analysis used anxiety as the dependent variable with independent variables at the individual level entered in this order: physical stress, life stress, and locus of control. The independent variables accounted for 21.4% of the variance in anxiety, and this was significant at the $p<.001$ level (Table 8).

Overall Regression

The overall regresssion revealed a direct path from physical stress to accident rates that was not included in the original model. When physical stress was entered into the regression of safety management, physical hazards, anxiety, experience, and danger level, the explained variance of accident rate increased from 15.7% to 20.6% when accident rate for 1985 only was the dependent variable (see Table 6). When physical stress was entered into the regression of the variables proposed to directly relate to accident rate for 1984 and 1985 combined, the explained variance increased from 15.3% to

Table 6

Path Analysis and Overall Regression Using 1985 Accident Rates

Variable	F(model)	t(last step)	R	R^2	Adjusted R^2
direct relationship					
Safety Management		-.655	.239	.057	.045
Danger Level		1.625	.275	.075	.058
Experience		-1.285	.337	.113	.078
Anxiety		1.001	.370	.136	.090
Physical Hazards	2.695*	-2.054	.397	.157	.099
direct and indirect relationship					
Physical Stress		2.005	.454	.206	.139
indirect relationship					
Life Stress		.078	.454	.206	.127
Locus of Control	2.241*	.093	.454	.206	.114

$p^* < .05$

Table 7

Path Analysis and Overall Regression Using 1984 and 1985 Accident Rates

Variable	F(model)	t(last step)	R	R^2	Adjusted R^2
direct relationship					
Safety Management		-1.195	.211	.045	.032
Danger Level		3.031	.300	.090	.066
Experience		-1.237	.358	.128	.093
Anxiety		-0.049	.358	.128	.081
Physical Hazards	3.787**	-2.964	.456	.208	.153
Indirect and direct relationship					
Physical Stress		1.270	.485	.235	.171
indirect relationship					
Life Stress		1.178	.501	.251	.176
Locus of Control	2.956*	-0.646	.505	.255	.169

$p^{**} < .005$
$p^{*} < .01$

Table 8

Path Analysis with Anxiety as Dependent Variable

Variable	F(model)	t(last step)	R	R^2
Physical Stress		7.193	.399	.160
Life Stress		3.722	.428	.183
Locus of Control	37.632***	-4.030	.463	.214

$^{***}p < .001$

23.5% (see Table 7). It appears that the model was correct in that it proposed physical stress to affect accident rate through its effect on anxiety but lacking in that it proposed no direct effect.

Life stress and locus of control affected accidents only indirectly. When they were directly regressed upon accident rate for 1985, they did not account for any additional explained variance. When they were directly regressed upon accident rate 1984 and 1985, it appeared that they accounted for an additional 2% variance. However, the adjusted $\underline{R}$ coefficients (Table 7) indicated that the increase in variance accounted for was due to the increase in number of predictors.

In summary, the path analysis fully supported the model and the overall regression supported the addition of one more path (see Figures 2 and 3). A slight revision of the model was in order. It was necessary to add the direct path from physical stress to accident rate to the model.

Cross-validation

The path analysis was cross-validated in two ways. In the first cross-validation, subsamples consisted of randomly selected companies. In the second cross-validation, subsamples consisted of randomly selected work groups. The company cross-validation was conducted by dividing the sample into two parts, one

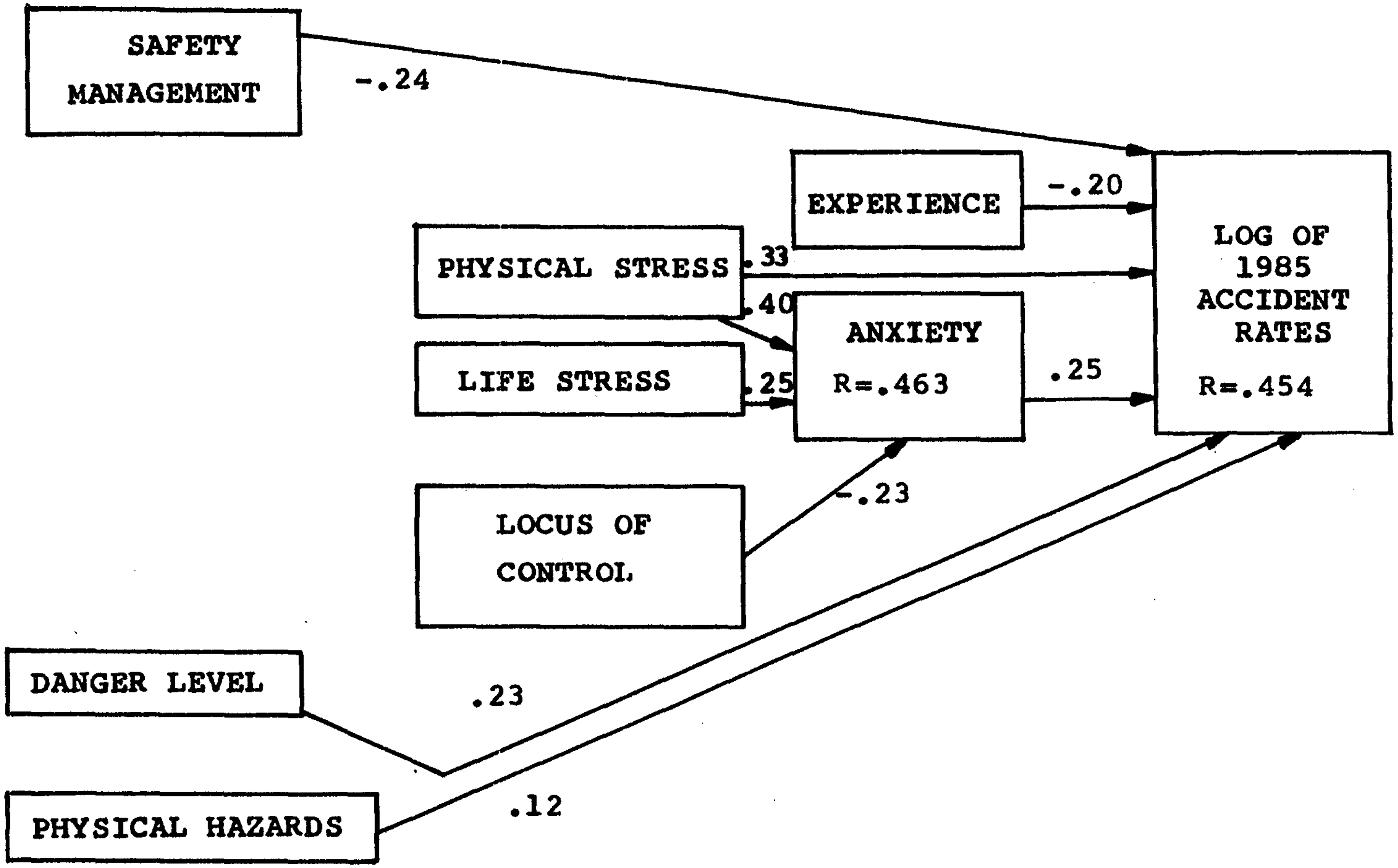

Figure 2. Results of the path analysis using 1985 accident rates.

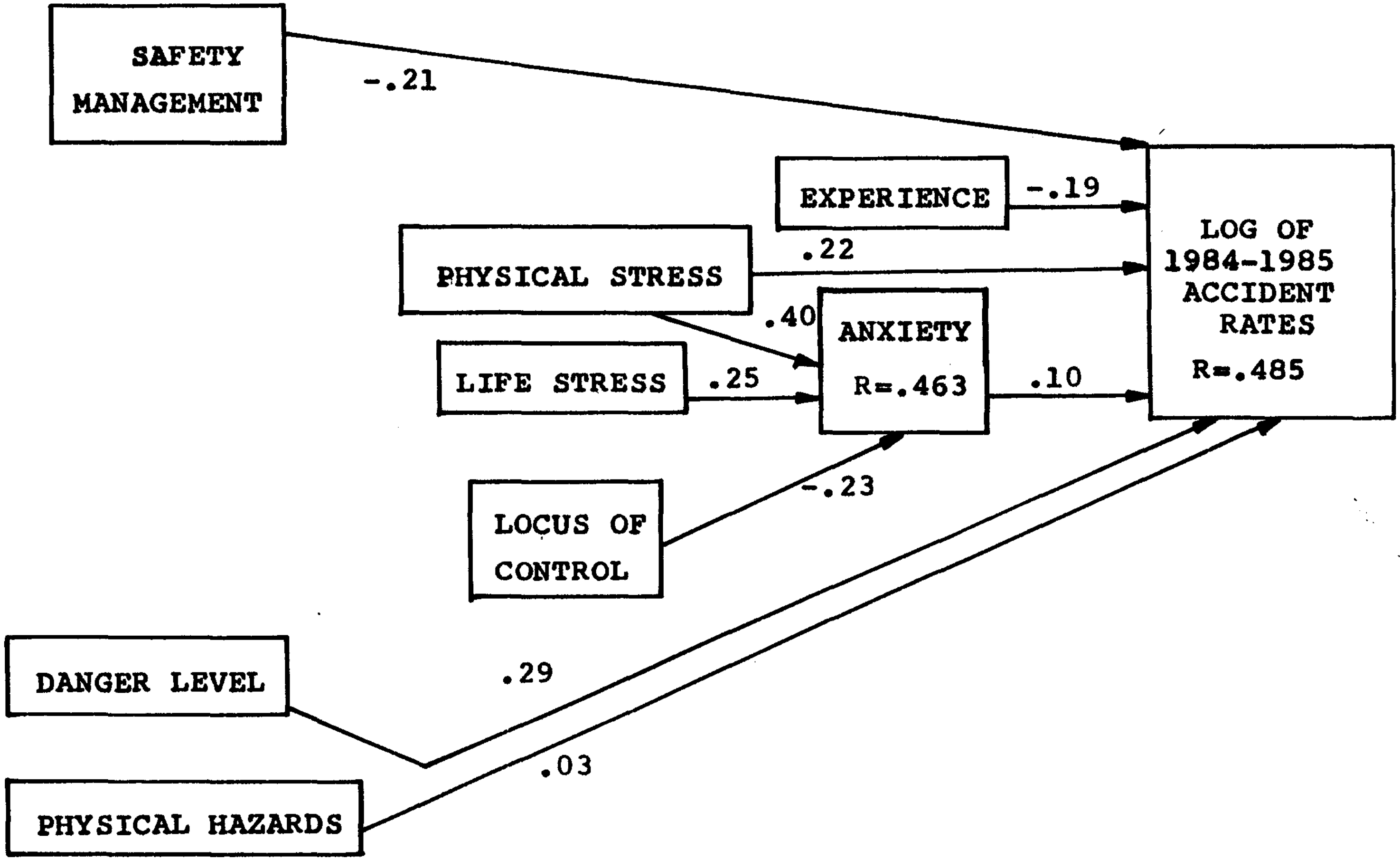

Figure 3. Results of the path analysis using 1984-1985 accident rates.

consisting of six companies and the other of three companies. Companies were left intact in order to test the generalizability of the model from one company to the next. Cross-validations were conducted using both the five variable and the six variable models of factors directly related to accident rate. Weights obtained from repeating all regression analyses on the larger part of the sample resulted in the following equations for the five variable model:

(1) Log Accident Rate for 1985=(-0.006637*Safety Management)+(0.026993*Danger Level)-(0.065958*Experience)+(0.060672*Anxiety)-(0.008451*Physical Hazards)+1.203895

(2) Log Accident Rate for 1984-1985=(-0.0453830*Safety Management)+(0.134761*Danger Level)-(0.030593*Experience)+(0.023712*Anxiety)-(0.17.1868*Physical Hazard)+1.848447.

The following equations resulted for the six variable model:

(3) Log Accident Rate for 1985=(-0.001390*Safety Management)+(0.024425*Danger Level)-(0.052176*Experience)+(0.037657*Anxiety)-(0.066831*Physical Hazard)+(0.138322*Physical Stress)+0.819017.

(4) Log Accident Rate for 1984-1985=(-0.040627*Safety Management)+(0.132442*Danger Level)

-(0.018152*Experience)+(0.002935*Anxiety)-

(0.224570*Physical Hazard+(0.124870*

Physical Stress)+1.501000.

The following equation resulted for anxiety:

(5) Anxiety=(0.613209*Physical Stress)+(0.197050*

Life Stress)-(0.285310*Locus of Control)+5.150613.

Each of these equations held up under cross-validation (see Table 9). Even under cross-validation, the six variable model was better than the five variable model originally proposed. For the six variable model, $\underline{R}$ increased from .454 to .468 using log accident rate of 1985 as the dependent measure, and from .485 to .577 using log accident rate of 1984-1985. The five variable model was not as predictive, although still significant. The coefficient of multiple correlation for log accident rate 1985 decreased slightly from .397 to .392, but increased for log accident rate 1984-1985 from .456 to .551. The cross-validations demonstrated that the equations as predicted by the theoretical model were stable across samples of organizations. An increase in $\underline{r}$ upon cross-validation is not a usual occurrence. In this particular sample, each company was likely to have contributed situational variability to the relationship between survey variables and accident rates. This variability was probably reduced when the sample was divided into two parts for the cross-validation.

Table 9

Cross-validations of the Path Analysis

Equation	Model	Full Sample R	Validation Sample R	r cross-validation
Sample divided into two subsamples of intact companies.				
	Dependent Variable=1985 Accident Rates			
(1)	5 variable	.397	.311	$.392^{*}$
(3)	6 variable	.454	.364	$.468^{**}$
	Dependent Variable=1984 and 1985 Accident Rates			
(2)	5 variable	.456	.427	$.551^{***}$
(4)	6 variable	.485	.471	$.577^{***}$
Sample divided into two subsamples of work groups.				
	Dependent Variable=1985 Accident Rates			
(1)	5 variable	.397	.482	.064
(3)	6 variable	.512	.205	.205
	Dependent Variable=1984 and 1985 Accident Rates			
(2)	5 variable	.456	.510	.218
(4)	6 variable	.485	.536	.219
Sample divided into two subsamples of individuals.				
	Dependent Variable=Anxiety			
(5)	3 variable	.463	.472	$.426^{****}$

$p^{*} < .05$
$p^{**} < .01$
$p^{***} < .005$
$p^{****} < .001$

To investigate this explanation, another cross-validation was performed. This time individual work groups rather than intact companies were randomly selected and assigned to one of the two subsamples. The work group cross-validation consisted of dividing the sample into a subsample of 26 groups and a subsample of 53 groups. Cross-validations were conducted using both the five variable and the six variable models of factors directly related to accident rate. Weights obtained from repeating all regression analyses on the larger part of the sample resulted in the following equations for the five varible model:

(1) Log Accident Rate for 1985=(-0.052489*Safety Management)+(0.113233*Danger Level)-(0.045814* Experience)+(0.036927*Anxiety) -(0.124982*Physical Hazards)+1.203895

(2) Log Accident Rate for 1984-1985=(-0.074356*Safety Management)+(0.134761*Danger Level)-(0.031400* Experience)+(0.005215*Anxiety) -(0.162788*Physical Hazards)+2.61244.

The following equations resulted for the six variable model:

(3) Log Accident Rate for 1985=(-0.036950*Safety Management)+(0.095552*Danger Level)-(0.043801* Experience)+(0.020362*Anxiety)-(0.161289* Physical Hazards)+(0.144439*Physical

Stress)+1.249063

(4) Log Accident Rate for 1984-1985=(-0.06186*Safety Management)+(0.085540*Danger Level)-(0.029777*Experience)+(0.018572*Anxiety)-(0.192065*Physical Hazards)+(0.111647*Physical Stress)+2.208386.

These equations did not hold up under cross-validation (see Table 9).

CHAPTER V

DISCUSSION

This final chapter begins with a discussion of the important findings in this study with emphasis on the theoretical relevance. A section on the limitations of the study including reliability, and internal and external validity follows. The chapter and dissertation ends with sections on the practical implications of the study and plans for future research.

Important Findings and Their Theoretical Relevance

Correlations. The variables in the model were found to be significantly intercorrelated in the directions that the model predicted. Plants which reported poorer safety management programs also reported higher levels of danger, physical hazards, physical stressors, and higher levels of anxiety, life stress and an external locus of control bias. The more experienced workers reported less life stress to a significant degree probably due to less reports of the common stressors such as new job assignments, new work schedules, and less job security.

Anxiety was found to correlate with life stress and locus of control but life stress and locus of control did not correlate with each other.

It is understandable that physical hazards, physical stressors, danger level, and safety management, were all interrelated because they were environmental characteristics of the same work place. Also, all were hypothesized to affect accident rates directly. It follows that anxiety, which was partially attributable to physical stressors and related directly to accident rate, was correlated with all the variables with which physical stress was correlated. According to the hypotheses, life stress and external locus of control orientation should lead to anxiety, and so it is appropriate that these two variables were significantly correlated with all the variables with which anxiety was correlated. Life stress and locus of control, however, were thought to be independent of each other. Thus, the lack of correlation between them was consistent with the model.

Secondly, the variables in the model were also significantly correlated with the dependent variables, log of accident rates for 1985 and log of accident rates for 1984-1985. Safety management, danger level, physical stress, experience, locus of control, and anxiety were all correlated with accident rates. Plants which reported poorer safety management, higher danger level, high physical stress, less job experience, or an external locus of control bias had higher accident rates. The anxiety correlation was found only for 1985 accident rates. It appears that anxiety can predict accidents only if accidents and anxiety are measured at proximal times. This finding is logical since anxiety is often a temporary condition rather than a stable trait. Life stress which was found to be a predictor of anxiety was measured in the most recent 6 months, so it is logical that anxiety resulting from life stress would only be related to accidents during the same limited time period.

The results of the correlations between survey variables and accident rates basically supported the hypotheses. One exception was that physical hazards were not found to correlate with accidents. Further discussion of this finding can be found under limitations.

Regressions. It was previously mentioned that one objective of this research was to expand the present theory about accidents. The organizational climate literature has focused on safety management issues. This study demonstrated that although safety management is a significant variable in accidents, other variables should also be included.

There is already adequate support for the predictive validity that experience, danger level, and physical hazards contribute to any model of accidents. This study corroborated these findings. Previous research supported the hypothesis that anxiety directly affects accident rate but studies were post-dictive in nature. This study supplied concurrent validity for the anxiety-accident relationship.

The path analysis conducted on the proposed model produced results that strongly supported the model. Safety management, danger level, physical hazards, experience, and anxiety accounted for a significant proportion of the accident rate variance.

Previous research also supported the stress, locus of control, and anxiety relationship. High stress directly increases anxiety, and locus of control moderates this effect with internals being less anxious. This study measured these variables in an industrial setting along with the more "typical accident" variables of safety management, physical hazards, danger level, and experience. Physical stress, life stress, and locus of control were found to be significant predictors of anxiety as previous research suggested. Locus of control and life stress affected accidents through anxiety only. Physical stress, however, had an indirect as well as a direct effect on accidents.

Upon conducting an overall regression on the variables in the model, a finding not previously included in the model was discovered. Physical stress correlated with accidents indirectly through anxiety as proposed, but also correlated directly with accidents, which was not originally proposed. When the model was revised to include the new finding, proportion of criterion variance accounted for was increased 3-5%. Upon examination, this finding is quite logical. Physical stress not only causes error by causing more anxiety but physical stress itself can cause error. For example, noise which is a physical stressor can increase anxiety thus increasing chance for error. Noise can also mask a warning signal thereby causing a person to miss the chance to avoid the hazard because the person does not even realize the hazard exists.

Uncontrollable physical stress and its effect on error has been explained in various ways. According to adaptive-cost hypothesis, stress drains a person's energy due to the extra effort required to maintain the same performance level. It takes more energy to do the same job in extreme heat so a person becomes tired, makes an error, and an accident results. According to information overload hypothesis, dealing with stress saps channel capacity. Since safety is often given secondary task status, errors of that type become more likely. Actually, the two hypotheses are quite similar.

Learned helplessness theory predicts that individuals lose the motivation to lessen the physical stress they are experiencing because past experience has demonstrated their actions to be futile. This lack of motivation extends to both the primary and secondary tasks, and inevitably an accident results. The theories were not tested in this study but are included merely to provide a rationale for the physical stress-accident finding. The theory supported by this study is that uncontrollable stressors in occupational settings affect accidents directly by creating a hazardous environment and/or affect accidents indirectly by increasing anxiety which leads to error.

The model held up strongly under cross-validation when the sample was divided into two subsamples of intact companies. Cross-validation coefficients actually increased rather than decreasing as they typically do in cross-validations studies as a result of the decrease in sample size necessary to conduct the analysis. This study was unique, however, in the sense that results in the path analysis were based on collapsing data across nine distinct companies with their particular characteristics. Therefore, when the sample was divided for the cross-validation, the randomizing effects of these characteristics probably decreased and Rs increased.

Evidence for this was provided by the second cross-validation in which the sample was divided into two subsamples of individual work groups rather than intact companies. In this situation, cross-validation did not hold up as it did for randomly selected companies.

Subunit Size. Analyses of subunit size added to the theoretical debate over its relationship to accidents. Smaller groups were found to have less accidents than larger groups on the whole. Small groups, less than 15 members, were bimodally distributed with one group at 0.0 accident rate and the other in a higher accident range. At the point where number of members is greater than 15, this 0.0 mode disappeared and only the higher accident rate mode remained. This helped to explain the previous research findings of both a positively correlated linear relationship and a curvilinear relationship between size and accidents.

Limitations of the Study

Reliability. The reliability analysis of the eight scales contained in the survey produced adequate results. Cronbach's alphas were in the .64-.78 range for safety management, physical hazards, danger level, experience, physical stressors, and anxiety. The alpha obtained for locus of control was lower than expected (.34). Alpha for life stress was lower than expected (.50). One item was removed from the anxiety and two from the locus of control scales. These items were not found to discriminate as they should have.

The lower reliability of the locus of control scale was believed to be partially due to the nature of the sample. Volunteer industrial subjects have been found to have a more internal locus of control than university students on whom research on the scale is based (Sims et al., 1984). The manufacturing sample used in this study was compared to the student sample used in pilot work. The university students obtained a mean of 8.2 (s=3.63) on the locus of control scale while the manufacturing sample obtained a significantly higher mean of 8.8 (s=2.59, t=-2.37, p<.05).

Internally oriented employees could have participated in the survey because they believed that through their participation they would have an impact on the work environment. Perhaps internal locus of control individuals simply were not afraid to participate and external locus of control individuals were. Internal locus of control workers would be more likely to feel that the consequences of their participation were in their control. Whatever the reason for the internal locus of control bias, it is apparent that the bias could have severely restricted the range of responses to the locus of control items. This restriction in range could be a contributor to the unreliability of the scale. The bias also may have attenuated the anxiety and locus of control effects due to restricted range.

On the life stress scale, several of the items, such as death of a spouse, death of a friend, and new job assignments, were rarely reported. The restriction in range of responses for these items could be responsible for the lower reliability of the scale.

The implications of the low reliabilities of the anxiety, life stress, and locus of control scales are obvious. Decreased reliability leads to decreased construct validity. The impact of these variables on each other and on accident rates is likely to have been underestimated in this study.

Internal Validity. The scales for experience, physical stress, and anxiety factored as expected. The danger level scale formed two scales. The first scale was comprised of items that established whether any hazard existed. The second scale was comprised of items that assessed the higher levels of danger. It is apparent that there may be a problem with the construct validity of the other factors. Only three locus of control items loaded on the locus of control scale. Safety management items were divided into two constructs; one was management in control factor and the other combined with physical hazard items as a messiness factor. There appeared to be a shiftwork construct consisting of life stress items with shiftwork. No life stress factor was extracted.

The low correlation of the locus of control scale used in the study and Rotter's locus of control scale suggests that the locus of control construct used in the survey should be renamed to belief about accident control. The low correlation, although significant, also indicates that belief about accident control is independent of Rotter's scale. However, the same hypotheses are made about the relationship of belief about accident control to accidents as those made for locus of control.

It appears that there is more than one way for the various items in the survey to combine. In a survey it is easy to propose distinct factors. In an applied environment, however, items from various sources blend together in some cases to form an unexpected factor. In this study, for example, physical hazards items blended with safety management items to form a messiness factor. It appears that the fundamentals of the proposed model are accurate, but the model may be more complicated than originally proposed.

If the problems with the construct in the survey are not eliminated, the internal validity of the study is in question. One cannot be confident that the obtained results truly support the proposed model since measurement of the independent variables may have been flawed.

External Validity. As previously mentioned, there may be a response bias present in the study. The sample on the average had a high internal locus of control score, indicating respondents tended to be more internally oriented than non-respondents. It is possible, therefore, that the results obtained from this sample are applicable only for individuals with an internal locus of control (a belief that they can control accidents). The data for non-respondents could change the obtained results dramatically if it were in fact true that the survey constructs interrelated differently for an external belief sample. One solution for this problem would be to make participation in the survey mandatory as a safety precaution.

It was mentioned that physical hazards did not correlate with accidents as expected. This could be due to 23% of respondents answering that no hazards existed in their work environment. The skewed distribution could be responsible for lowered correlations between the hazard checklist and accidents. Also, the fact that there was a very high negative correlation between safety and physical hazards suggests that a good safety program may limit the number of accidents due to physical hazards.

In both of these cases, the external validity of the study is threatened. In the first case, a response bias may invalidate the use of survey variables to predict accident rates. Since accident rates were based on the entire sample, any measures used to predict accident rates should be representitive of the entire sample. The potential response bias indicates that the data obtained from the survey may not have been truly representitive of the sample. In the second case, the lack of correlation between physical hazard and accidents may have resulted from the skewed distribution of the hazard checklist. Multiple regression requires that independent variables be normally distributed so this violation may have resulted in an underestimate of the true contribution of physical hazards to accidents.

Although the regression models were supported by the cross-validation at the company level, cross-validation at the work group level was not supported thus limiting the external validity of the path model. The regression models can be generalized to new companies with confidence, but, generalization to specific work groups outside the validation sample should be attempted with caution.

Practical Implications

The data obtained from this survey can be used to build a causal model of human error related accidents that can be applied to occupational settings. All the survey variables can be measured and used to pinpoint problem areas in a particular company. For example, if poor safety management is found to be responsible for a large percentage of variance in accident rate for a particular foundry, a program for improved safety management can be introduced. Or, if life stress is found to be a particular problem in a company, a counseling program could be installed. Solutions could be at the individual or organizational level depending on the problem and so the appropriate type of consultant should be contacted (i.e., clinical or organizational).

Future Research

Accident rates for the work groups in the sample will be collected for October 1985-October 1986. The analyses conducted with the dependent variables in this study will then be repeated using these rates as the dependent variable so that predictive validity in addition to concurrent validity can be established.

The nonlinear relationship found between organizational subunit size and accident rates is worthy of further investigation. Future research plans include analysis of the interdependencies among task type, organization, survey variables and subunit size. This analysis would hopefully explain the origins of the nonlinear relationship.

Another future research objective is to revise the survey. The life stress and locus of control scales can be improved as already mentioned. The life stress scale will be revised to include more commonly occurring items. Instead of death of a spouse, or death of a friend which received few positive responses, other items from the Ruch and Holmes (1971) stress scale will be included (e.g., mortgage over $10,000; minor violations of the law will be represented by the statement "I usually drive 5-10 miles over the speed limit").

Three things will be done to improve the locus of control scale, which will be renamed belief about accident control. First, more items will be pilot tested with an industrial sample rather than a student sample as used for the pilot test of this study. The purpose of the pilot test will be to find more items that significantly correlate with Rotter's (1966) scale. Secondly, a forced choice format will be developed similar to Rotter's method. Hopefully, this will improve the reliability of the scale. The forced choice response mode was avoided in this study due to its potential for complicating the survey and confusing respondents. Lastly, an incentive system for persuading individuals with an external belief orientation to respond to the survey will be developed. If these individuals participate in the study, the belief scale will be improved, and the response bias along with its negative implications for validity will be eliminated.

The physical hazard checklist did not correlate with the dependent variables as it was expected to. As mentioned, 24% of reports were that no hazards from the checklist existed. If the hazard checklist was compared across several industries including more hazardous environments such as mining, the chance of finding a correlation would be improved.

The factor analysis extracted some unexpected factors of shiftwork, safety management control of accidents, and a messiness factor. In this one study, it is difficult to determine whether these factors were a function of the metal industry studied or were enduring constructs of the survey. To further investigate the model, another future plan involving this research is to conduct the revised survey across several industries such as mining, chemical, and agricultural. Results of this extended analyses will uncover useful information about the appropriate factor structure, as it is now unknown whether the new factors obtained in this study should be ignored, used in substitution of factors originally proposed, or used in combination with the original factors. If the results of the factor analysis obtained in this study receive further support, future research plans will include building a model based on these factors.

In the very long run, the model can be extended and research conducted on accidents other than occupational types. Automobile accidents, a definite problem in the United States, could possibly be decreased due to knowledge gained by applying this model.

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of doctor of philosophy.

3/5/86
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